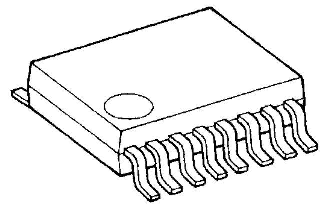
TENTATIVE TOSHIBA Bi-CMOS Integrated Circuit Silicon Monolithic

TB6598FN/FNG

Dual Full-Bridge Driver for Stepping Motors

The TB6598FN/FNG is a 2-phase bipolar stepping motor driver employing an LDMOS structure with low ON-resistance for output drive transistors. By applying four input signals (EN1, EN2, IN1, IN2), it is possible to control the rotation direction (forward/reverse) of 2-phase/1-2-phase stepper motor.

It is also possible to achieve constant-current drive (PWM chopper drive).



Weight: 0.07 g (typ.)

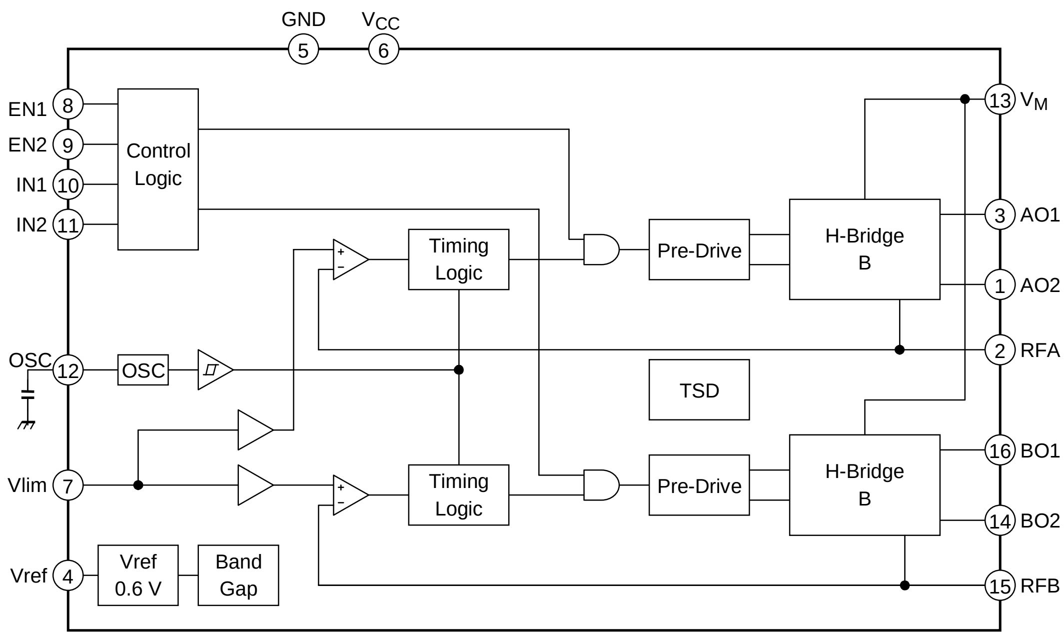
Features

- Motor supply voltage: $V_M \leq 15$ V (max)
- Control supply voltage: $V_{CC} = 2.7$ V to 6 V
- Output current: $I_{out} \leq 0.8$ A (max)
- Low ON-resistance: 1.5 Ω (upper side + lower side typ. @ $V_M = 5$ V)
- Constant-current control (PWM chopper drive)
- Standby (power-saving) mode
- On-chip thermal shutdown circuit (TSD)
- Compact package: SSOP-16

TB6598FNG:
TB6598FNG is a Pb-free product.
The following conditions apply to solderability:
*Solderability
1. Use of Sn-63Pb solder bath
   *solder bath temperature = 230°C
   *dipping time = 5 seconds
   *number of times = once
   *use of R-type flux
2. Use of Sn-3.0Ag-0.5Cu solder bath
   *solder bath temperature=245°C
   *dipping time = 5 seconds
   *the number of times = once
   *use of R-type flux

- This product has a MOS structure and is sensitive to electrostatic discharge. When handling the product, ensure that the environment is protected against electrostatic discharge by using an earth strap, a conductive mat and an ionizer. Ensure also that the ambient temperature and relative humidity are maintained at reasonable levels.
- Install the product correctly. Otherwise, breakdown, damage and/or degradation in the product or equipment may result.

Block Diagram



Some functional blocks, circuits, or constants may be omitted or simplified in the block diagram for explanatory purposes.

Pin Functions

Pin Name	Pin No.	Functional Description	Remarks
AO2	1	Output 2 (Ch. A)	Ch. A motor winding connection pin
RFA	2	Winding current detection pin (Ch. A)	
AO1	3	Output 1 (Ch. A)	Ch. A motor winding connection pin
Vref	4	Internal reference voltage	+0.6 V (typ.)
GND	5	Ground pin	
V_{CC}	6	Small-signal power supply pin	$V_{CC\ (ope)}$ = 2.7 V to 5.5 V
Vlim	7	Winding current setting pin	Icoil (A) = Vlimit (V)/external RF (Ω)
EN1	8	Enable input 1	
EN2	9	Enable input 2	
IN1	10	Control input 1	
IN2	11	Control input 2	
OSC	12	Internal oscillation frequency setting pin	Connect an oscillator capacitor externally
V_M	13	Motor power supply pin	$V_{M\ (ope)}$ = 4.5 V to 13.5 V
BO2	14	Output 2 (Ch. B)	Ch. B motor winding connection pin
RFB	15	Winding current detection pin (Ch. B)	
BO1	16	Output 1 (Ch. B)	Ch. B motor winding connection pin

Truth Table 1

EN1 (EN2)	IN1 (IN2)	AO1 (BO1)	AO2 (BO2)	Mode
L	*	OFF	OFF	ALL OFF
H	H	L	H	Reverse
	L	H	L	Forward

"*" indicates "don't care."

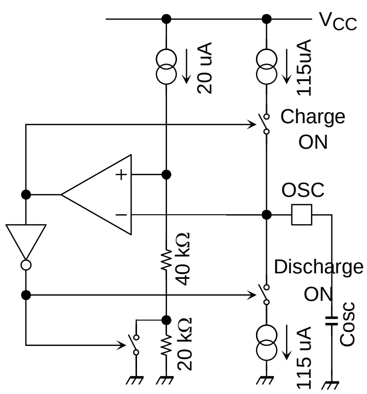
Truth Table 2

EN1	EN2	Mode
L (Note)	L (Note)	Standby
L	H	Operation
H	L	
H	H	

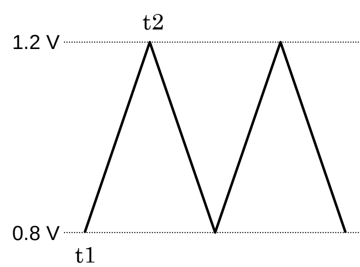
Note: VINL (EN1 = EN2) ≦ 0.5 V.

Operating Description

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.



Oscillator circuit



Vosc waveform

- The internal oscillation frequency is determined by charging and discharging an external capacitor (Cosc).

$$\mathrm{Vosc} = \frac{1}{\mathrm{Cosc}}\int i\,dt\ ,$$

$$\Delta\mathrm{Vosc} = I \times (t1 - t2)/\mathrm{Cosc},$$

$$\frac{1}{t1 - t2} = \frac{I}{\Delta\mathrm{Vosc}\cdot\mathrm{Cosc}}\ ,$$

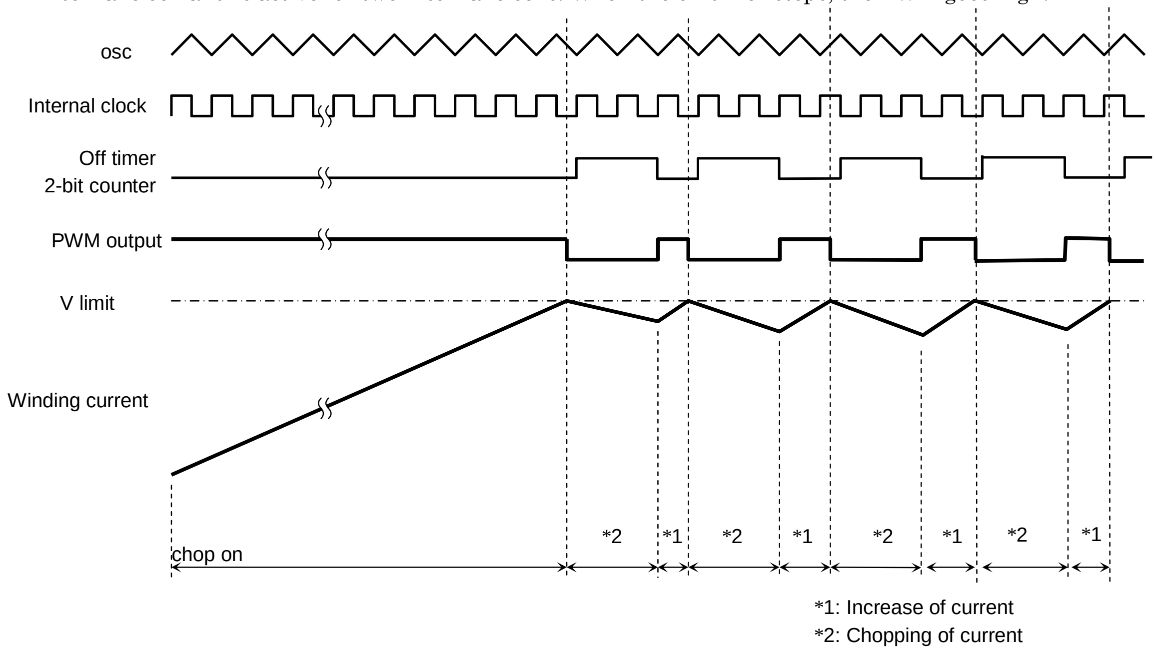
$$\mathrm{fosc} = \frac{1}{2\,(t1 - t2)} = \frac{I}{2\cdot\Delta\mathrm{Vosc}\cdot\mathrm{Cosc}}\ ,$$

$$= \frac{1}{2\times 0.4/115\ \mu\mathrm{A}\times\mathrm{Cosc}} = \frac{1}{6.957\times 10^{3}\times\mathrm{Cosc}}$$ (theoretical formula).

- Chopper control

  The winding current flows while the output drive transistor is On. When the V_{RF} reaches the limit voltage level (Vlimit), the comparator detects it and turns off the output drive transistor.

  The oscillator output is squared to generate an internal clock. The off timer starts on the edge of the internal clock and is active for two internal clocks. When the off timer stops, the PWM goes high.

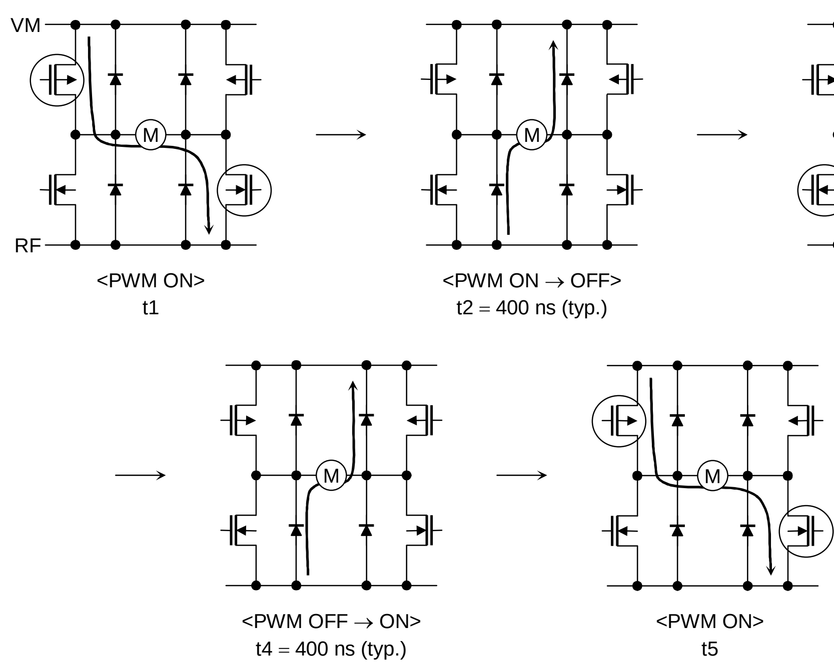


The PWM control limits the winding current to a level determined by the current value (I_O) as expressed in the equation below:

$$I_O = \text{Vlimt}/\text{RNF}.$$

- PWM control function

  When PWM control is provided, normal operation and short brake operation are repeated.
  To prevent penetrating current, dead time t2 and t4 are provided in the IC.



Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit	Remarks
Power supply voltage	V_M	15	V	
	V_{CC}	6		
Input voltage	V_{IN}	−0.2 to 6	V	IN1, IN2, EN1 and EN2 pins
Output current	I_{OUT}	0.8	A	
Power dissipation	P_D	0.78 (Note 1)	W	
Operating temperature	T_{opr}	−20 to 85	°C	
Storage temperature	T_{stg}	−55 to 150	°C	

Note 1: When mounted on a glass-epoxy PCB (50 mm × 30 mm × 1.6 mm, Cu area: 40%)

The absolute maximum ratings of a semiconductor device are a set of specified parameter values that must not be exceeded during operation, even for an instant.

If any of these ratings are exceeded during operation, the electrical characteristics of the device may be irreparably altered, in which case the reliability and lifetime of the device can no longer be guaranteed.

Moreover, any exceeding of the ratings during operation may cause breakdown, damage and/or degradation in other equipment. Applications using the device should be designed so that no maximum rating will ever be exceeded under any operating conditions.

Before using, creating and/or producing designs, refer to and comply with the precautions and conditions set forth in this document.

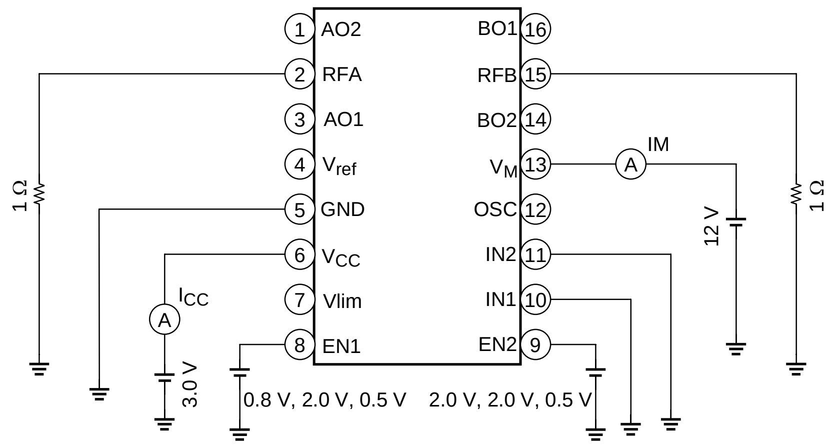
Operating Range (Ta = −20 to 85°C)

Characteristics	Symbol	Min	Typ.	Max	Unit
Power supply voltage (V_{CC})	V_{CC}	2.7	3	5.5	V
Power supply voltage (V_M)	V_M	2.5	5	13.5	V
Output current	I_{OUT}	—	—	0.6	A
Limit voltage	V_{limit}	GND	—	Vref	V
OSC frequency	f osc	—	—	1	MHz
Chopping frequency	f_{chop}	20	—	250	kHz

Electrical Characteristics (unless otherwise specified, V_{CC} = 3 V, V_M = 12 V, Ta = 25°C)

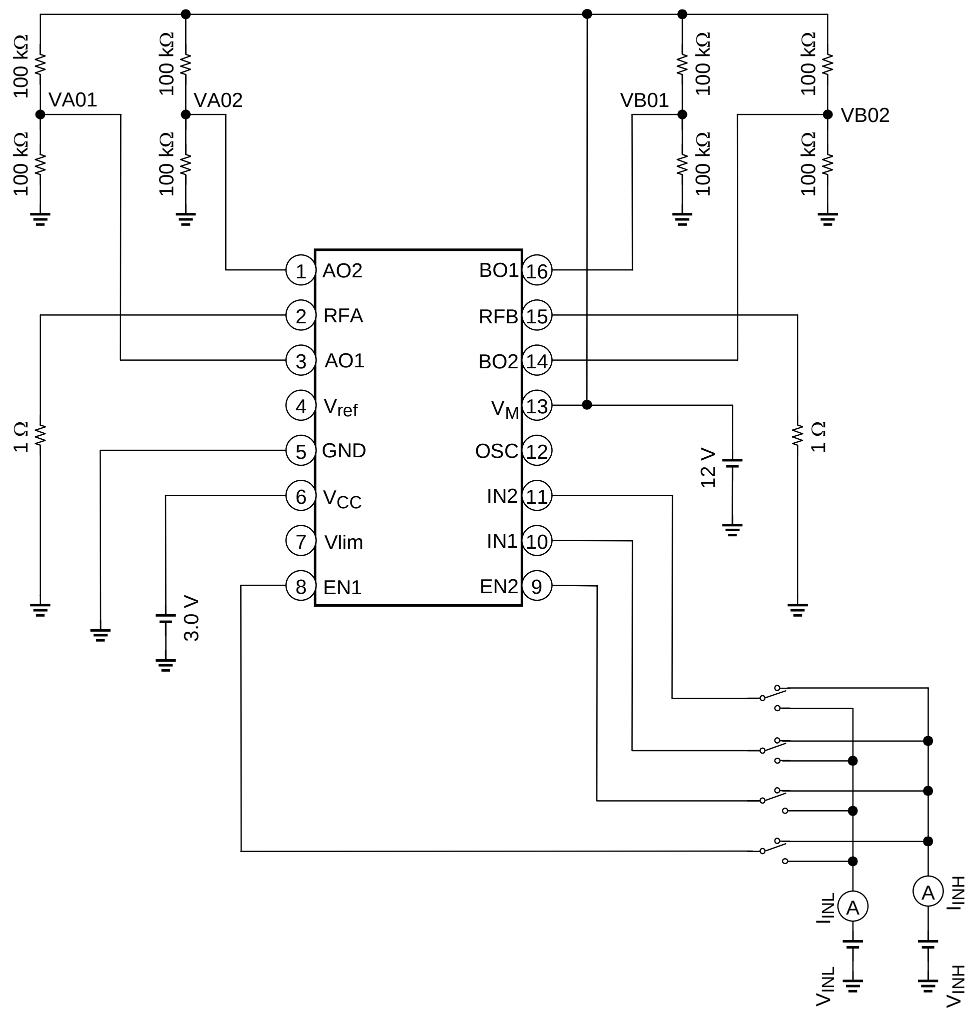
Characteristics		Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Supply current		I_{CC1}	1	1ch ON EN1 = 0.8 V, EN2 = 2.0 V	—	1.4	3	mA
		I_{CC2}	1	2ch ON EN1 = EN2 = 2.0 V	—	1.4	3	mA
		I_{CC3}	1	Standby mode EN1 = EN2 = 0.5 V	—	7	15	μA
		I_{M1}	1	1ch ON, Output open EN1 = 0.8 V, EN2 = 2.0 V	—	1.9	3.0	mA
		I_{M2}	1	2ch ON, Output open EN1 = EN2 = 2.0 V	—	1.9	3.0	
		I_{M3}	1	Standby mode EN1 = EN2 = 0.5 V	—	—	1	μA
Control circuit	Input voltage	V_{INH}	2		2	—	V_{CC} + 0.2	V
		V_{INL1}	2		−0.2	—	0.8	
		V_{INL2}	2	Standby mode	−0.2	—	0.5	
	Hysteresis voltage	$V_{IN (HIS)}$	—	(Design target value)	—	0.2	—	
	Input current	I_{INH}	2	VIN = 3 V	5	15	30	μA
		I_{INL}	2	VIN = GND	—	—	1	μA
Output saturating voltage		$V_{sat (U + L)}$	3	I_O = 0.2 A	—	0.3	0.4	V
				I_O = 0.6 A	—	0.9	1.2	
Output constant-current detection level		V_{RF}	4	R_{RF} = 0.1 Ω, V_{ref} = 0.6 V	0.565	0.6	0.635	V
Reference voltage		V_{ref}	5	No load	0.57	0.6	0.63	V
Reference voltage current capacity		I_{ref}	5	Source (ΔV_{ref} = 50 mV)	—	—	100	μA
Input current at winding current setting pin		$I_{IN (limit)}$	6	V_{limit} = GND	—	—	1	μA
Output leakage current		$I_{L (U)}$	7	V_M = 15 V	—	—	1	μA
		$I_{L (L)}$	7		—	—	1	
Diode forward voltage		$V_{F (U)}$	8	I_O = 0.6 A	—	1	1.2	V
		$V_{F (L)}$	9	I_O = 0.6 A	—	1	1.2	
Oscillation frequency		f osc	10	C_{osc} = 220 pF	430	530	630	kHz
Capacitor charge current		I_{C1}	11	V_{osc} = 0 V	—	115	—	μA
Capacitor discharge current		I_{C2}	11	V_{osc} = 2 V	—	115	—	μA
Thermal shutdown circuit operating temperature		T_{SD}	—	(Design target value)	—	170	—	°C
Thermal shutdown hysterisis		ΔT_{SD}	—		—	20	—	°C

Test Circuit 1: I_{CC}1, I_{CC}2, I_{CC}3, IM1, IM2, IM3

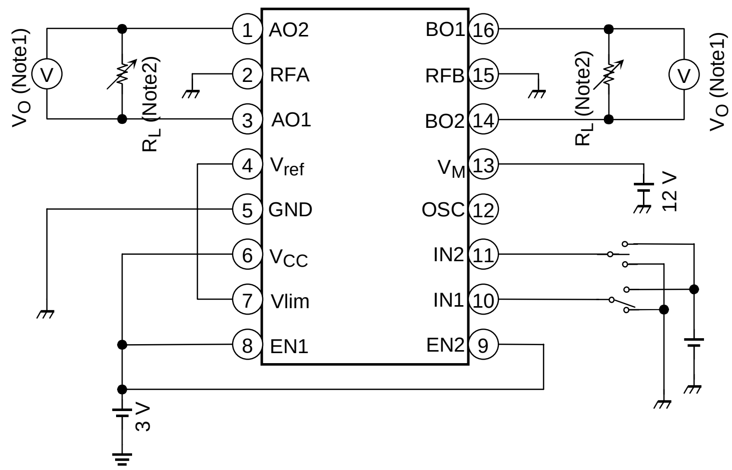


I_{CC1}, IM1: EN1 = 0.8 V, EN2 = 2.0 V
I_{CC2}, IM2: EN1 = 2.0 V, EN2 = 2.0 V
I_{CC3}, IM3: EN1 = 0.5 V, EN2 = 0.5 V

Test Circuit 2: V_{INH}, V_{INL1}, V_{INL2}, I_{INH}, I_{INL}



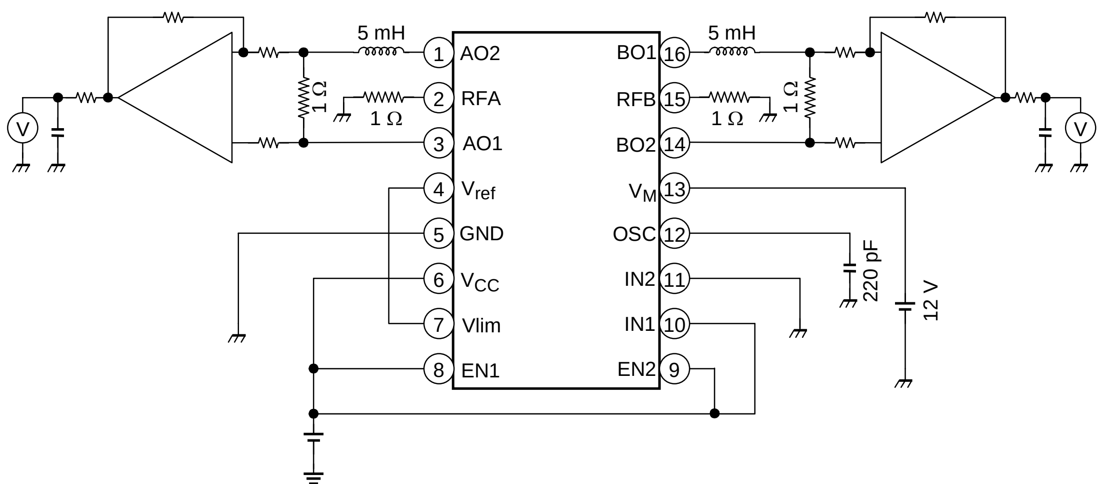
Test Circuit 3: $V_{SAT\ (U + L)}$



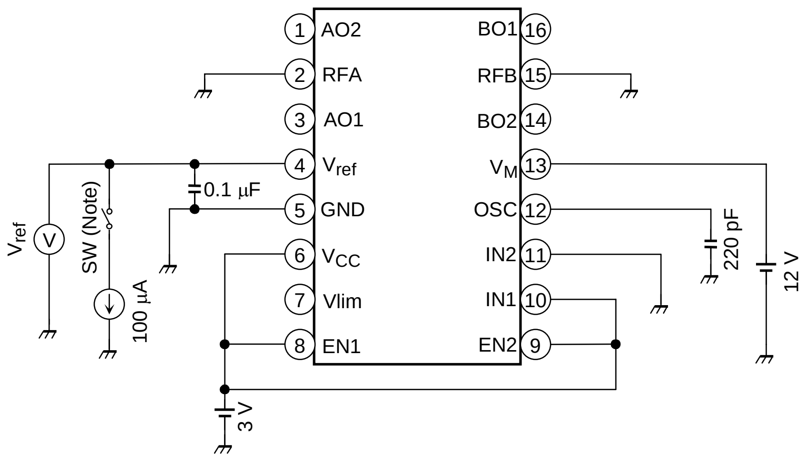
Note1: $V_{SAT\ (U + L)} = 12 - V_O$

Note2: Calibrate I_O to 0.2 A / 0.6 A by RL.

Test Circuit 4: V_{RF}

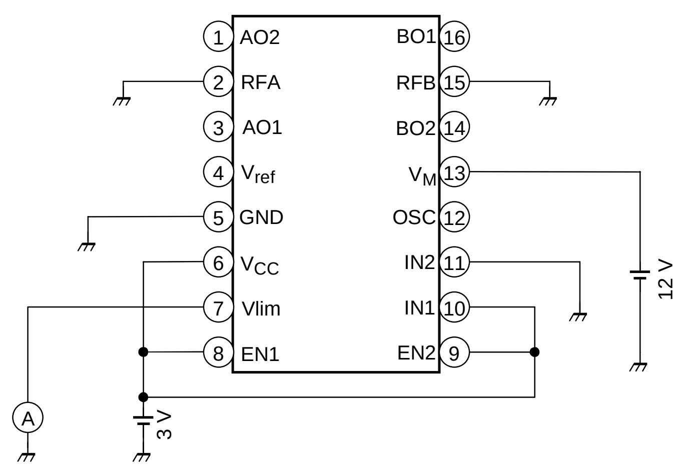


Test Circuit 5: V_{ref}, Iref

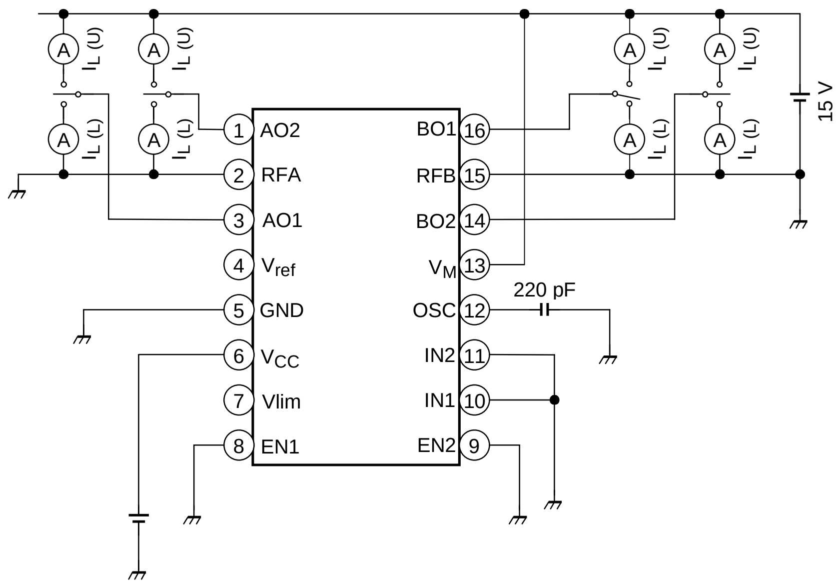


Note: 1. Vref: SW = OFF
2. Iref: The Vref voltage descent at the time of SW = ON checks below 50 mV.

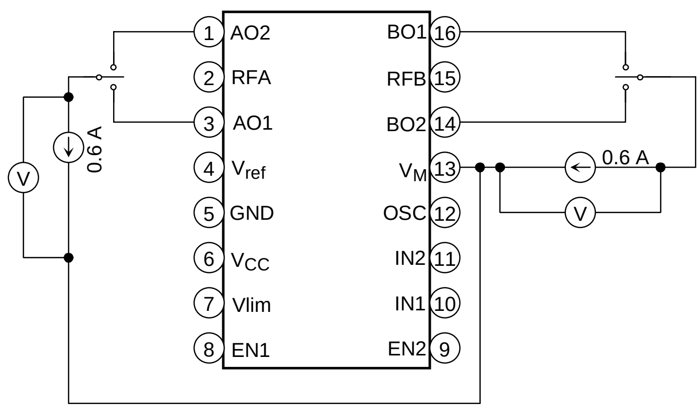
Test Circuit 6: $I_{IN\ (limit)}$



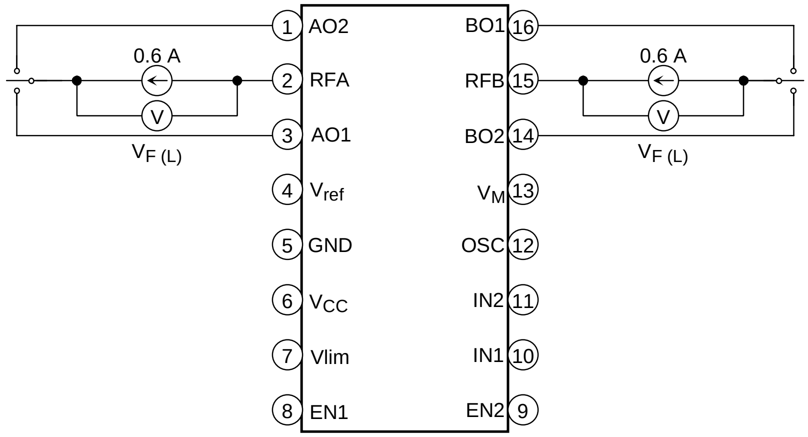
Test Circuit 7: $I_{L\ (U)}$, $I_{L\ (L)}$



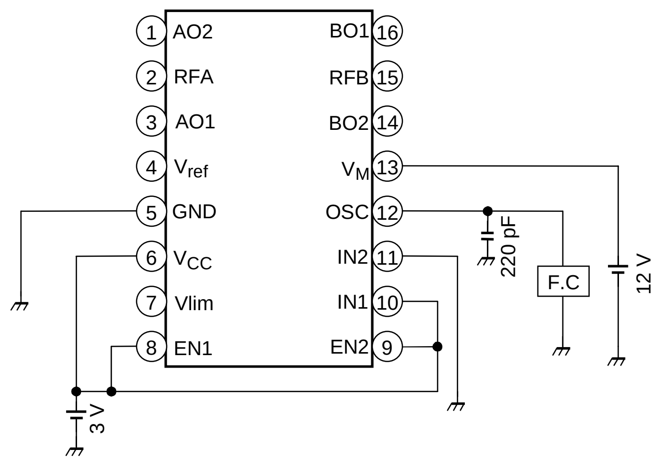
Test Circuit 8: $V_{F\ (U)}$



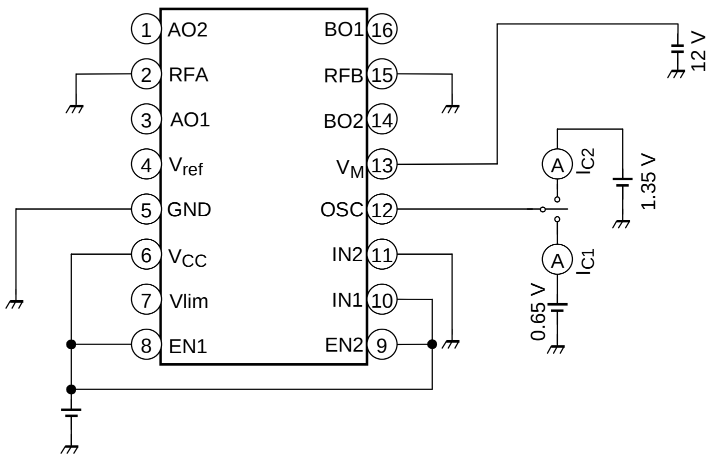
Test Circuit 9: $V_{F\ (L)}$



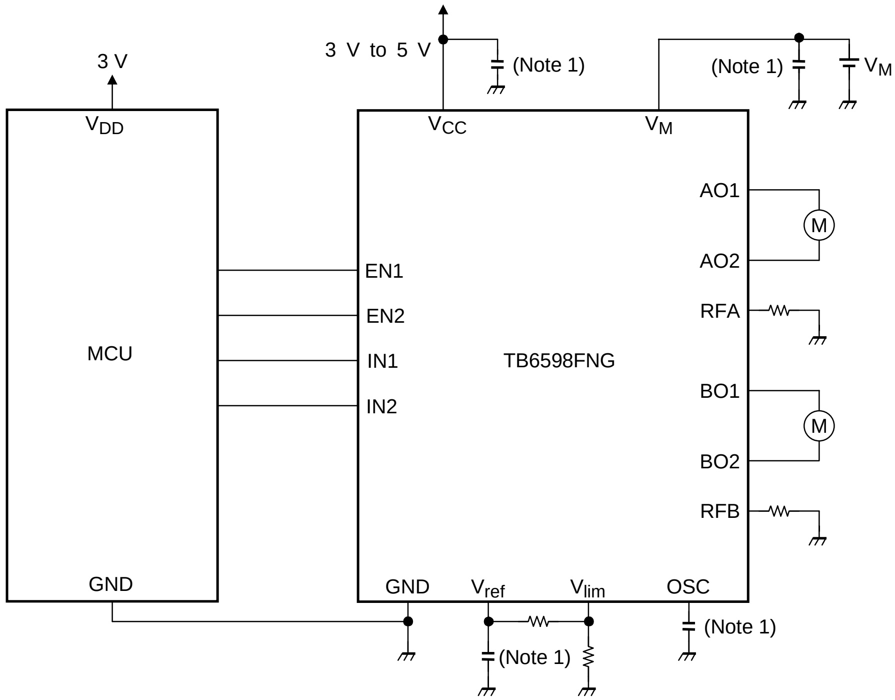
Test Circuit 10: f_{OSC}



Test Circuit 11: I_{C1}, I_{C2}

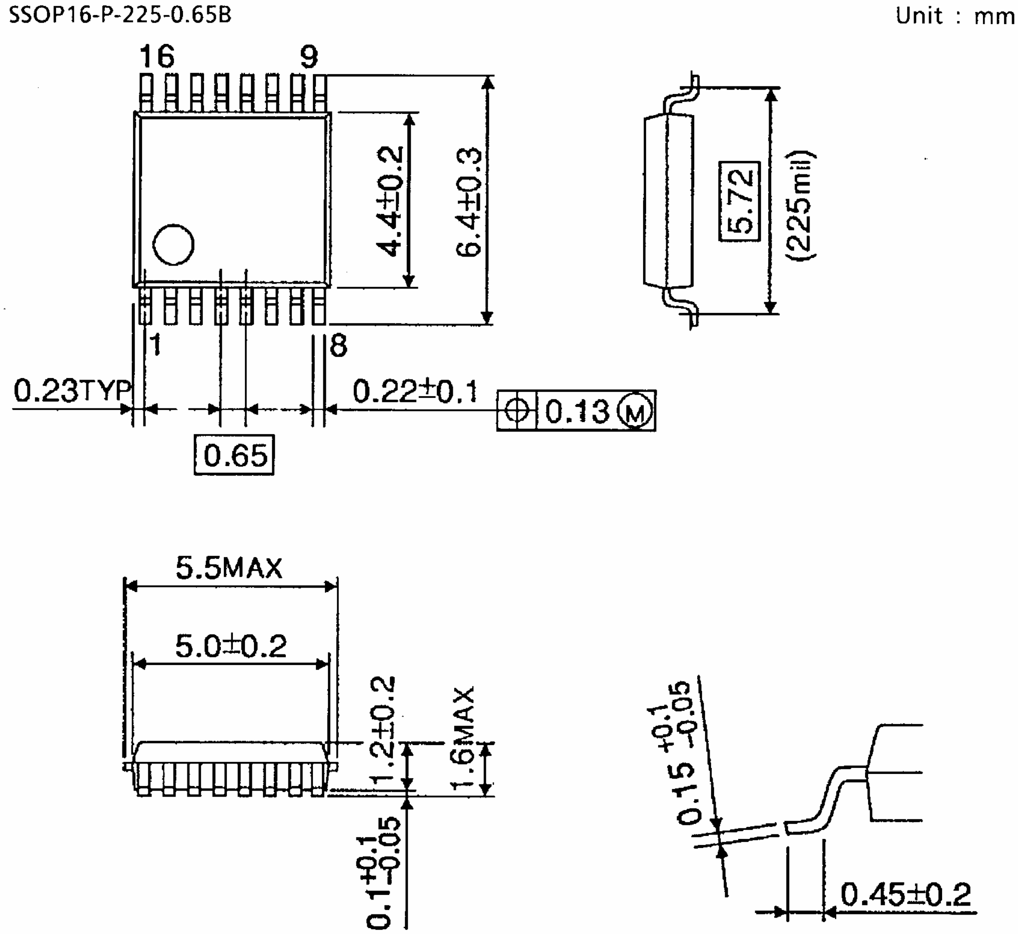


Application Circuit Example



Note 1: Noise suppression capacitors and oscillator capacitors should be connected as close as possible to the IC.

Package Dimensions



Weight: 0.07 g (typ.)

Notes on Contents

1. Block Diagrams
Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

2. Equivalent Circuits
The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. Timing Charts
Timing charts may be simplified for explanatory purposes.

4. Maximum Ratings
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5. Application Circuits
The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required in the mass production design phase.

In furnishing these examples of application circuits, Toshiba does not grant the use of any industrial property rights.

6. Test Circuits
Components in test circuits are used only to obtain and confirm device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure in application equipment.

Handling of the IC
Ensure that the product is installed correctly to prevent breakdown, damage and/or degradation in the product or equipment.

Overcurrent Protection and Heat Protection Circuits
These protection functions are intended only as a temporary means of preventing output short circuits or other abnormal conditions and are not guaranteed to prevent damage to the IC.

If the guaranteed operating ranges of this product are exceeded, these protection features may not operate and some output short circuits may result in the IC being damaged.

The over-current protection feature is intended to protect the IC from temporary short circuits only.

Short circuits persisting over long periods may cause excessive stress and damage the IC. Systems should be configured so that any over-current condition will be eliminated as soon as possible.

Counter-Electromotive force
When the motor reverses or stops, the effect of counter-electromotive force may cause the current to flow to the power source.

If the power supply is not equipped with sink capability, the power and output pins may exceed the maximum rating.

The counter-electromotive force of the motor will vary depending on the conditions of use and the features of the motor. Therefore make sure there will be no damage to or operational problem in the IC, and no damage to or operational errors in peripheral circuits caused by counter-electromotive force.